

LIFE CYCLE OF TROPICAL CYCLONE JUDY AS REVEALED BY ESSA II AND NIMBUS II

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ABSTRACT

Three ESSA II views and a Nimbus II view of tropical cyclone Judy illustrate an important general characteristic of tropical cyclone development. This is the tendency of the apparent center of circulation, as seen in satellite photographs, to move from the edge of major overcast cloudiness in the weaker stages to a more central position as the storm intensifies, and to become almost symmetrical to the main cloud shield in the most intense stages. As the storm decreases in intensity the center of circulation again assumes an asymmetric relationship to the major overcast cloud area. Some aspects of the physical plausibility of this relationship are briefly discussed.

1. INTRODUCTION

In an earlier paper Fett [1] described an important characteristic of the formative stage of tropical cyclone development revealed clearly for the first time by meteorological satellites. This was that the center of circulation of tropical depressions, generally with maximum sustained surface wind speeds of less than 30 kt., tends to be defined by convective cloud bands of rather narrow width, located along the edge of the major overcast cloud area. With further intensification the center of circulation becomes obscured and the overcast cloud shield appears to expand about the storm center. Satellite views of the more intense storms have generally indicated that the center of circulation, or in these cases the eye of the storm, is in a position very nearly symmetrical to the main cloud shield. Some excellent examples of this condition have recently been published by Fritz et al. [2]. It may be concluded from these examples that a progressive tendency for the center to assume a more and more central position with respect to major cloudiness during the process of intensification is inherent in typhoon development.

Another aspect, occasionally viewed, is a tendency for the storm to "run down" in the same manner that it intensifies [3]. A few rare pictures of decaying storms that were not obscured by land or frontal effects show the circulation center of the storm again in a more asymmetrical position near the edge of major overcast cloudiness.

In all prior studies, no single storm was viewed during all stages to illustrate adequately this tendency. With the recent advent of ESSA II, the new Automatic Picture Transmission (APT) satellite, and Nimbus II, the complete development and decay of typhoon Judy was monitored by equipment at Tan Son Nhut AFB, Saigon. For the first time a single storm was observed in all

stages at the appropriate times. The views obtained indicate that Judy exemplified the qualities described above.

2. TROPICAL DEPRESSION JUDY, MAY 25, 1966

On this day a tropical depression in the South China Sea was viewed by both ESSA II and Nimbus II: Figure 1 shows the Nimbus view obtained on pass 131 at 0326 GMT. Low-level cloud banding in the northwest quadrant tends to define a circulation center near 15° N., 116° E. The initial depression advisory by the Joint Typhoon Warning Center (JTWC) at Guam placed a center at 14.0° N., 116.5° E. at 0600 GMT approximately $2\frac{1}{2}$ hr. after the Nimbus photo. This position is in reasonable agreement with the estimate derived through the satellite photo which was gridded to an accuracy of plus or minus 30 n.mi. Maximum sustained surface wind speeds were indicated by Guam to be 30 kt. From the Nimbus photo one can see that the apparent center of circulation lies in a more open area northwest of the major overcast convective cloudiness associated with the storm system. The depression at this time conforms to the Stage C, "Comma Configuration," described in a previous paper [1]. Maximum sustained surface wind speeds in this stage of development have normally been found to fall within the range of 20 to 30 kt., in close agreement with the JTWC estimate and with available surface reports plotted in figure 1. From Manila's 200-mb. 0000 GMT wind report plotted near 15.3° N., 120.5° E. and from the indications of upper wind direction denoted by cirrus plumes (dashed arrows) one can deduce that even in this early stage of development an anticyclone or ridge had formed aloft over the overcast area. A comparison of Manila's 200-mb. wind with that from station 663 on the southern coast of China (near 22° N., 112° E.) reveals that a broad

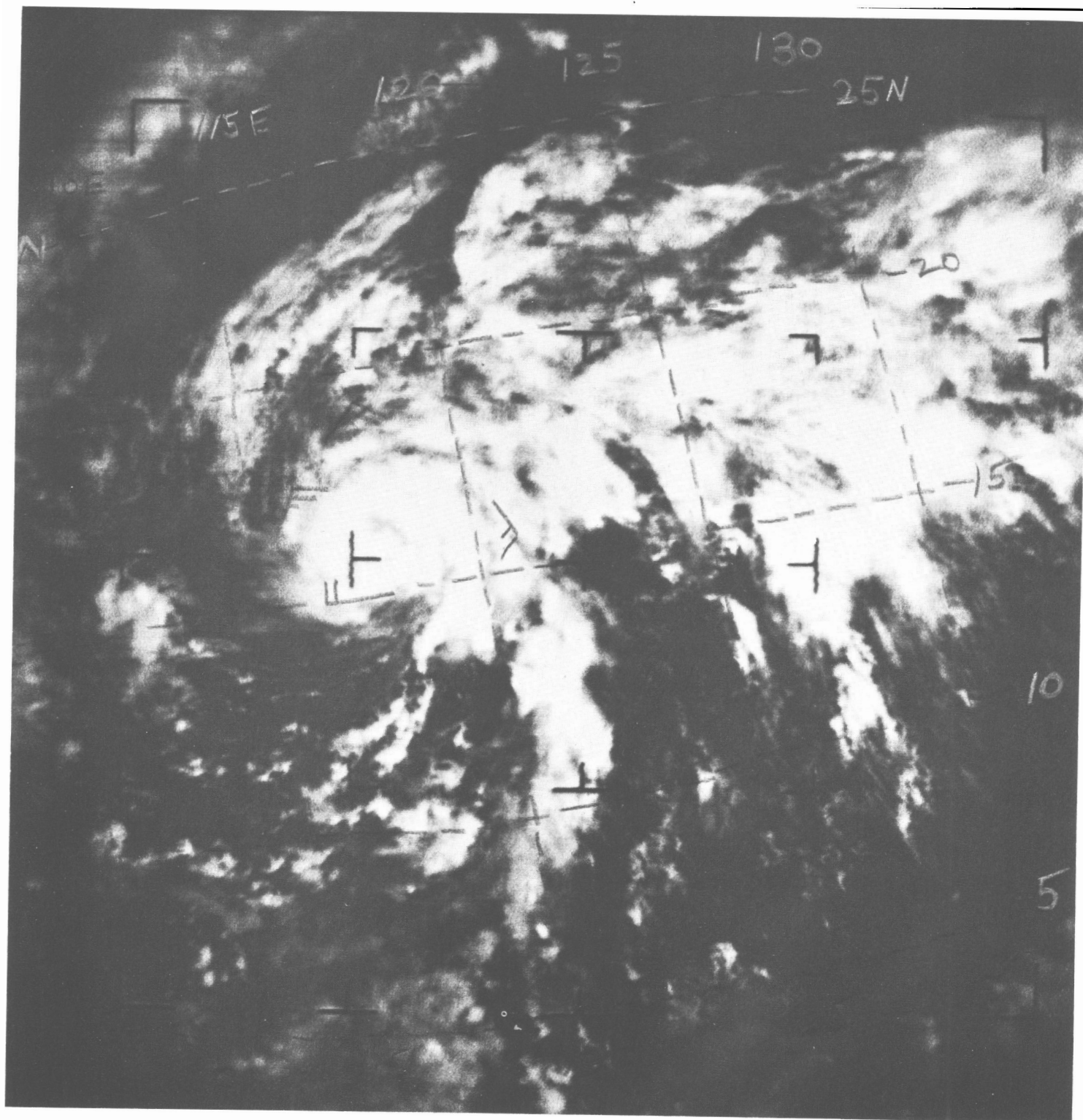


FIGURE 2.—An ESSA II view of typhoon Judy on May 27, 1966, pass 1109, 0028 GMT. Surface winds for 0000 GMT in the typhoon area are plotted.

maximum sustained surface wind speeds estimated at 70 kt. Figure 2 shows an ESSA II view of typhoon Judy at 0028 GMT on May 27, 1966. At this time the eye of the storm was pinpointed by the JTWC at 16.5° N., 117.8° E.

Maximum wind speeds were estimated at 75 kt. The position is in good agreement with general indications of banding in the APT photograph and available surface reports plotted in figure 2. Note that the center is now

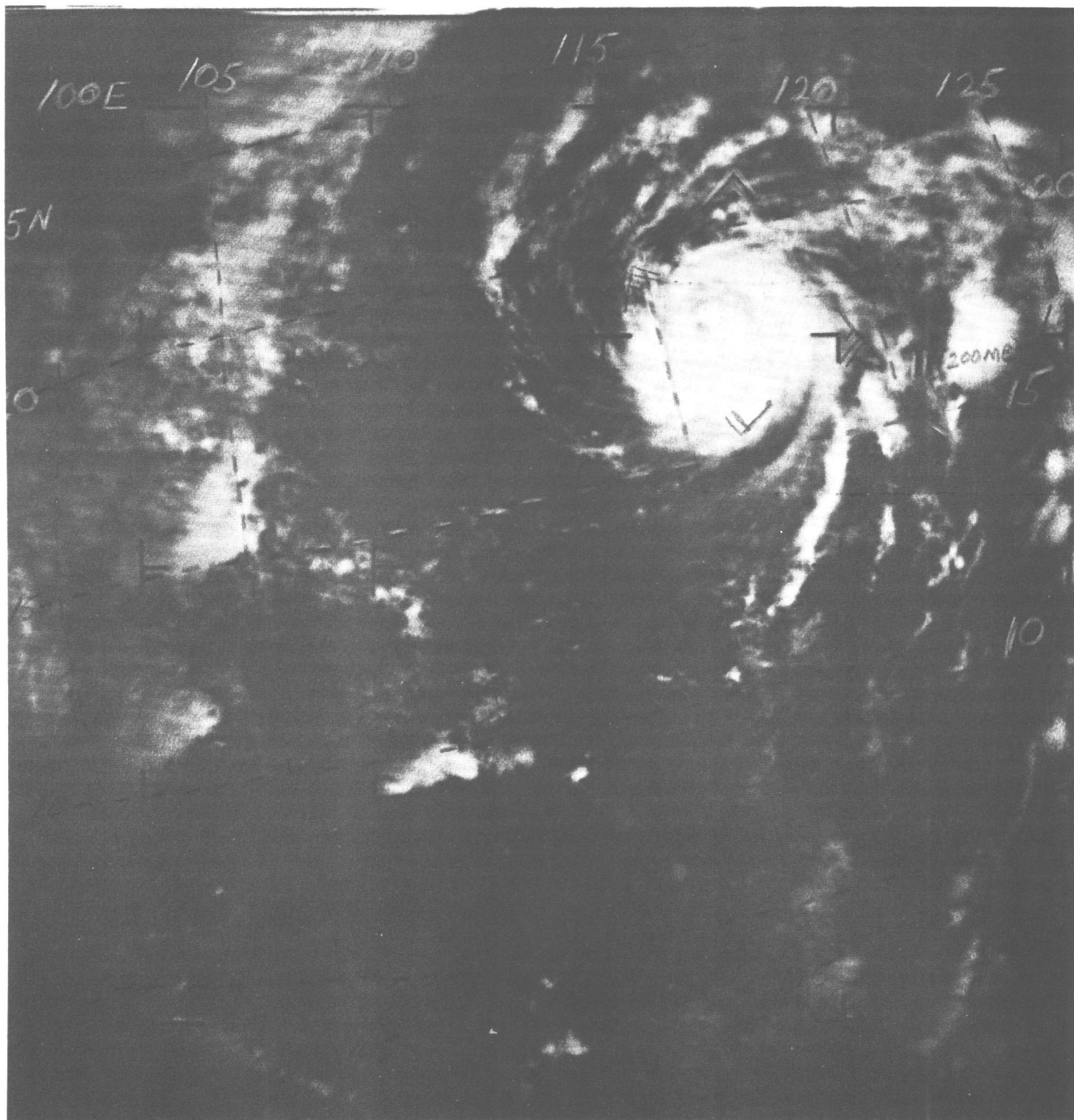


FIGURE 3.—An ESSA II view of typhoon Judy on May 28, 1966, pass 1121 at 0105 GMT. Surface and 200-mb. winds for 0000 GMT in the typhoon area are plotted.

embedded within the heavy overcast cloudiness. The cloudiness stretching far to the east between latitudes 15° and 20° N. coincided with the trailing edge of the weak polar front. Effects of this frontal interaction diminished on the following day when Judy was again viewed by

ESSA II (fig. 3). This picture, taken on May 28, 1966, at 0105 GMT, shows typhoon Judy near its maximum intensity. The JTWC reported its position at 0000 GMT, May 28 as 18.5° N., 116.7° E., with maximum winds of 85 kt. The eye of the storm can be seen in the ESSA

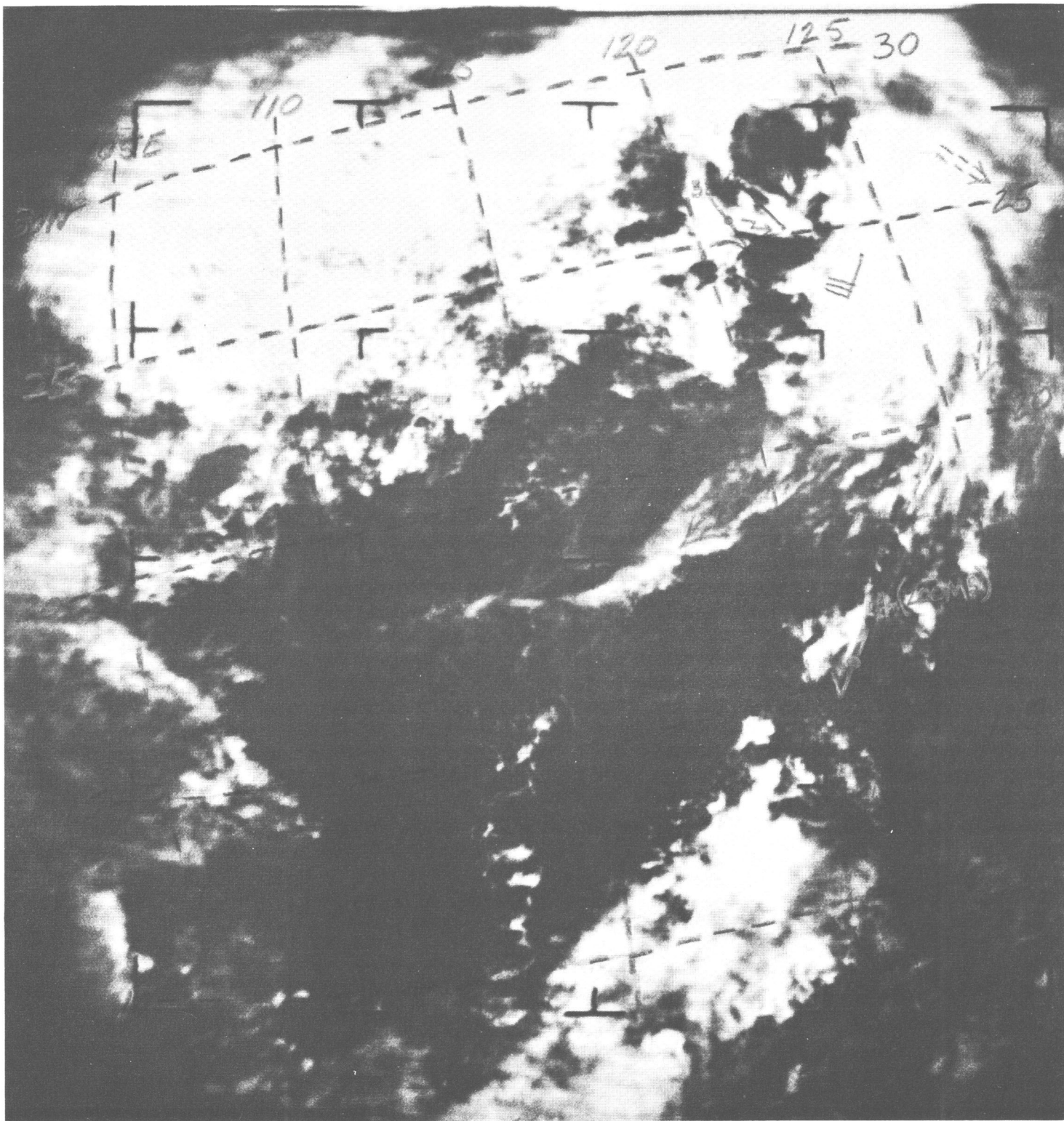


FIGURE 4.—An ESSA II view of tropical storm Judy on May 31, 1966, pass 1160 at 0057 GMT. Surface and 200-mb. winds for 0000 GMT in the storm area are plotted. Dashed arrows show probable 200-mb. flow deduced from the alignment of cirrus striations.

photograph near 18° N., 116° E. This position, based on a gridding accuracy for the photograph of plus or minus 30 n.mi., is in close agreement with the JTWC estimate. As in the previous figure, the eye of the storm is well within the confines of the major overcast cloudiness.

4. TROPICAL STORM JUDY, MAY 31, 1966

The final APT photograph on May 31 at 0057 GMT shows tropical storm Judy shortly after it traversed the island of Taiwan (fig. 4). The effects of the high moun-

tain range on the east side of the island weakened the storm appreciably as it moved off to sea to the northeast. The APT picture, gridded to an accuracy of plus or minus 30 n.mi., shows the center of circulation again on the edge of the major overcast cloudiness near 25° N., 123.5° E. At 0600 GMT the JTWC relocated the storm's position, based on surface reports, at 26.2° N., 126.4° E. Maximum winds were estimated at 55 kt. Reliability of this fix was indicated as poor and probably was in error, since the storm center would have had to move toward the northeast at a speed of 50 kt. in order to have attained this position from the time of the APT fix, and this speed appears excessive based on scanty wind reports available. The surface wind reports at 0000 GMT, plotted in figure 4, support the reliability of the APT fix.

A comparison of Judy at this final stage of development with the initial view shown in figure 1 reveals the great similarity of appearance that is characteristic of the two stages. The centers of circulation are both on the edge of the main overcast cloudiness which dominates primarily the eastern semicircle of the storms. Anticyclonic flow aloft over the convective areas is apparent in both photos as revealed by the cirrus striations and plotted 200-mb. reports. The "Comma Configuration" is clearly shown when one constructs a smooth curve southward from the center of circulation tangent to the curved bands leading into the vortex centers. Streamline analyses in this configuration reveal a low-level asymptote of convergence under the main overcast area.

5. CONCLUSIONS

The APT views of tropical cyclone Judy clearly reveal a characteristic which appears to be inherent in the life cycle of typhoon development and decay. The fact that the center of circulation is found outside the areas of major convection in the weaker stages fully supports the contention made by Malkus [4] who emphasized the importance of the development of an *eye* before hurricane intensity could be attained.¹ It is at this stage that the zone of major convergence is transferred from outlying

¹ More recent findings indicate that in some rare storms, wind speeds of minimum hurricane strength are occasionally found even with no wall cloud and with the center of circulation near the edge of the major cloudiness. In these instances, marked banding and small radius of curvature are noticeable in the satellite photos. Such configuration has never typified the more intense storms and has been quite transitory in nature.

areas, and the eye-wall cloud complex becomes the dominant and driving force of the storm. One can readily appreciate that any vertical motion near the center of circulation when it is on the edge of major cloudiness, in a relatively dry environment, could result in only a small release of latent heat. Hence only a minor reduction of pressure could occur and wind speeds would generally be light. Once the center is surrounded by convective bands or a wall cloud, rising air in this moist environment can release a maximum amount of heat resulting in lower surface pressures and correspondingly higher wind speeds. The reversion to the comma configuration in the decaying stage signifies the dissipation of the wall cloud and transference of major convergence and vertical motion again to the convergence asymptotes. A complete treatment of this phenomenon is beyond the scope of this paper, but is certainly worthy of further detailed consideration.

ACKNOWLEDGMENTS

This paper and the history of Judy were made possible by satellite photos available to a remote field location—one of many now operational throughout the world. This format is infinitely superior to the coded NEPANS or schematic nephanalyses previously available. The value of such real time data, particularly in the Tropics, where conventional sources are limited, cannot be overemphasized. In the realm of detecting, tracking, and monitoring the intensity of tropical cyclones, application of such data is having a truly revolutionary impact.

REFERENCES

1. R. W. Fett, "Some Characteristics of the Formative Stage of Typhoon Development: A Satellite Study," paper presented at National Conference on Physics and Dynamics of Clouds, Chicago, Ill., Mar. 1964, 10 pp. plus figures. U.S. Weather Bureau, Washington, D.C. (multilithed). See also, "The Upper Level Structure of the Formative Tropical Cyclone," *Monthly Weather Review*, vol. 94, No. 1, Jan. 1966, pp. 9-18.
2. S. Fritz, L. F. Hubert, and A. Timchalk, "Some Inferences from Satellite Pictures of Tropical Disturbances," *Monthly Weather Review*, vol. 94, No. 4, Apr. 1966, pp. 231-236.
3. R. W. Fett, "TIROS Photos and Mosaic Sequences of Tropical Cyclones in the Western Pacific During 1962," Meteorological Satellite Report No. 32, U. S. Weather Bureau, Washington, D.C., Sept. 1964, 38 pp.
4. J. Malkus, "Tropical Weather Disturbances—Why So Few of Them Become Hurricanes," *Weather*, vol. 13, No. 3, Mar. 1958, pp. 75-89.

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